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Arterial Performance Measurement in the Transportation Performance Measurement System (PeMS)

Overview

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What is PeMS?

1. Software system that collects transportation data
2. Computes performance measures and stores them
3. Provides many ways to visualize transportation data
4. Is a foundation for performance reporting on the transportation system

Caveats:

1. It doesn't replace engineering or planning judgment.

Who is BTS?

Company Mission

- Help clients leverage all data to enhance the performance of the transportation system (we're "data geeks")

Product

- Transportation Performance Measurement System, PeMS

Project History

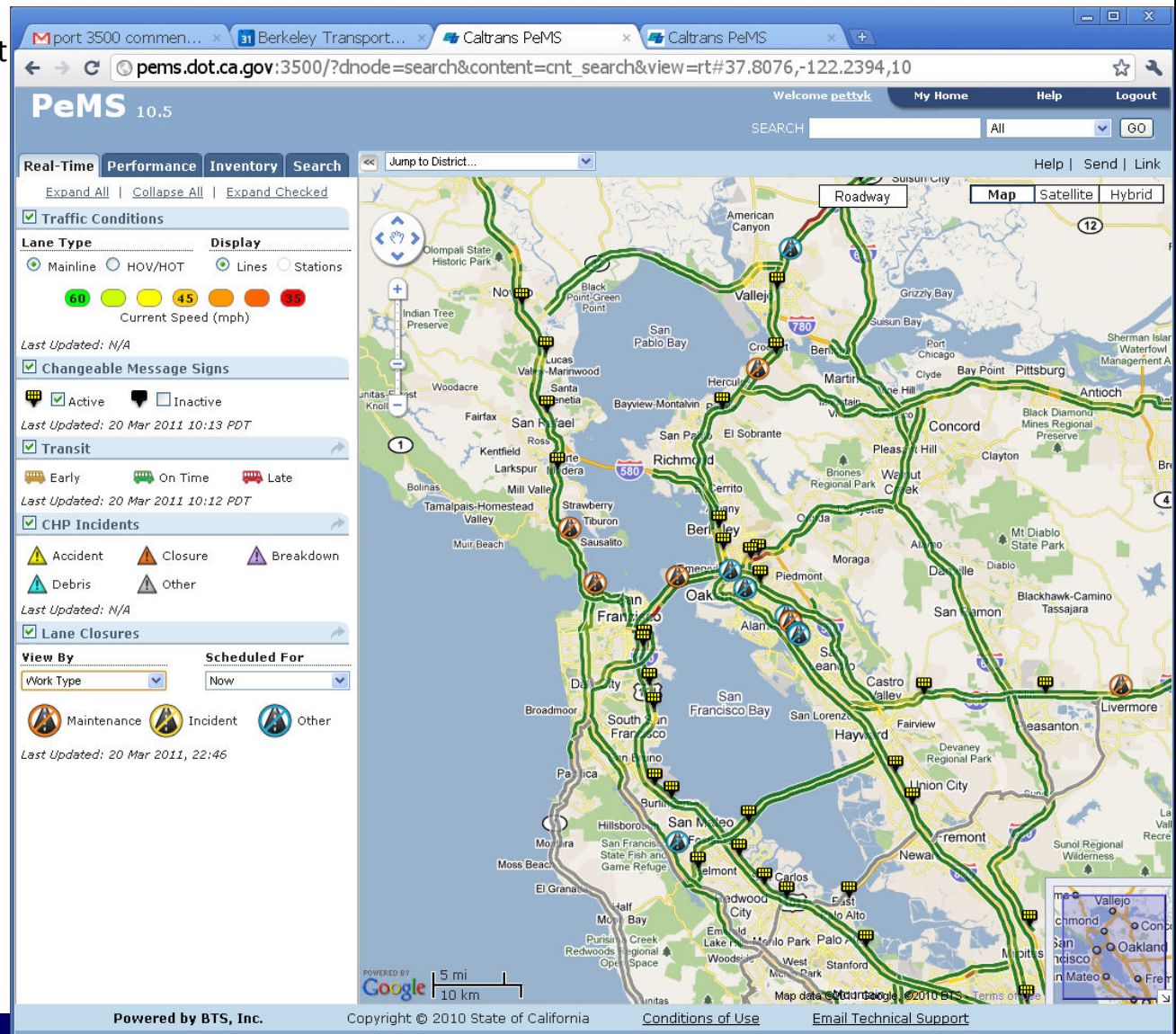
- Initiated as a research project at UC Berkeley in 1998
- Started with simple freeway data, expanded to incidents, arterials, transit
- First deployment was inside of Caltrans

Major Clients:

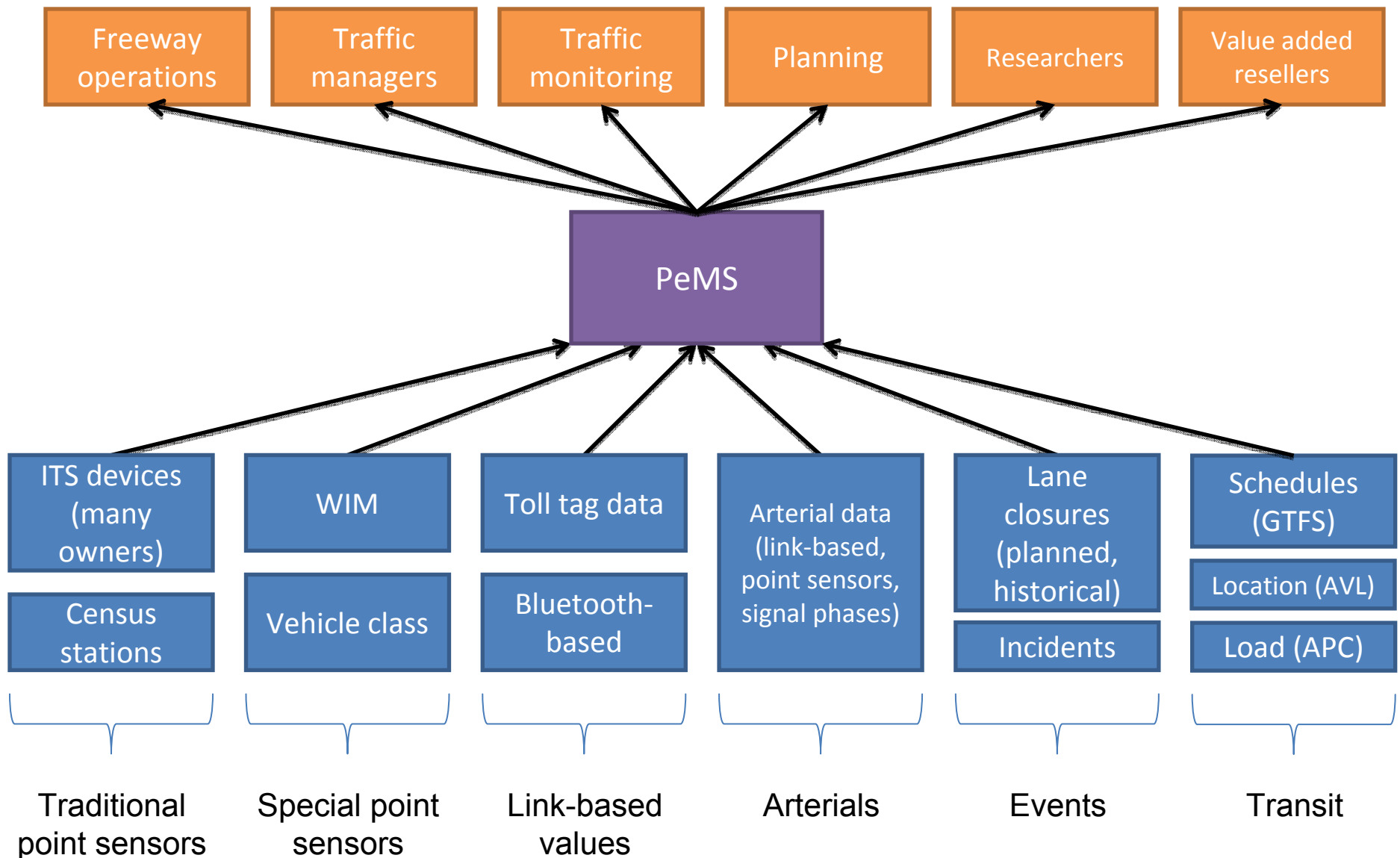
- California Department of Transportation, Utah Department of Transportation, Washington Department of Transportation, SANDAG, Los Angeles Department of Transportation, Southern California Association of Governments, Attiki Odos Motorway (Athens, Greece)

What is PeMS (details)?

- Real-time Archive Data Management System (rt-ADMS)
- PeMS collects many types of detailed, raw data in real-time and in batch mode – primarily freeway operations data
- It processes the data in real-time:
- Diagnostics
- Imputation for missing values
- Aggregations
- Fusing of different sources
- Computes many performance measures (travel time, delay, etc).
- Large # of tools to plot, chart, etc.
- Stores raw data forever
- Caltrans deployment:
- Has 32,000 sensors reporting every 30 seconds
- Over 19,000 census stations
- Started in 1999, ~12TB of data

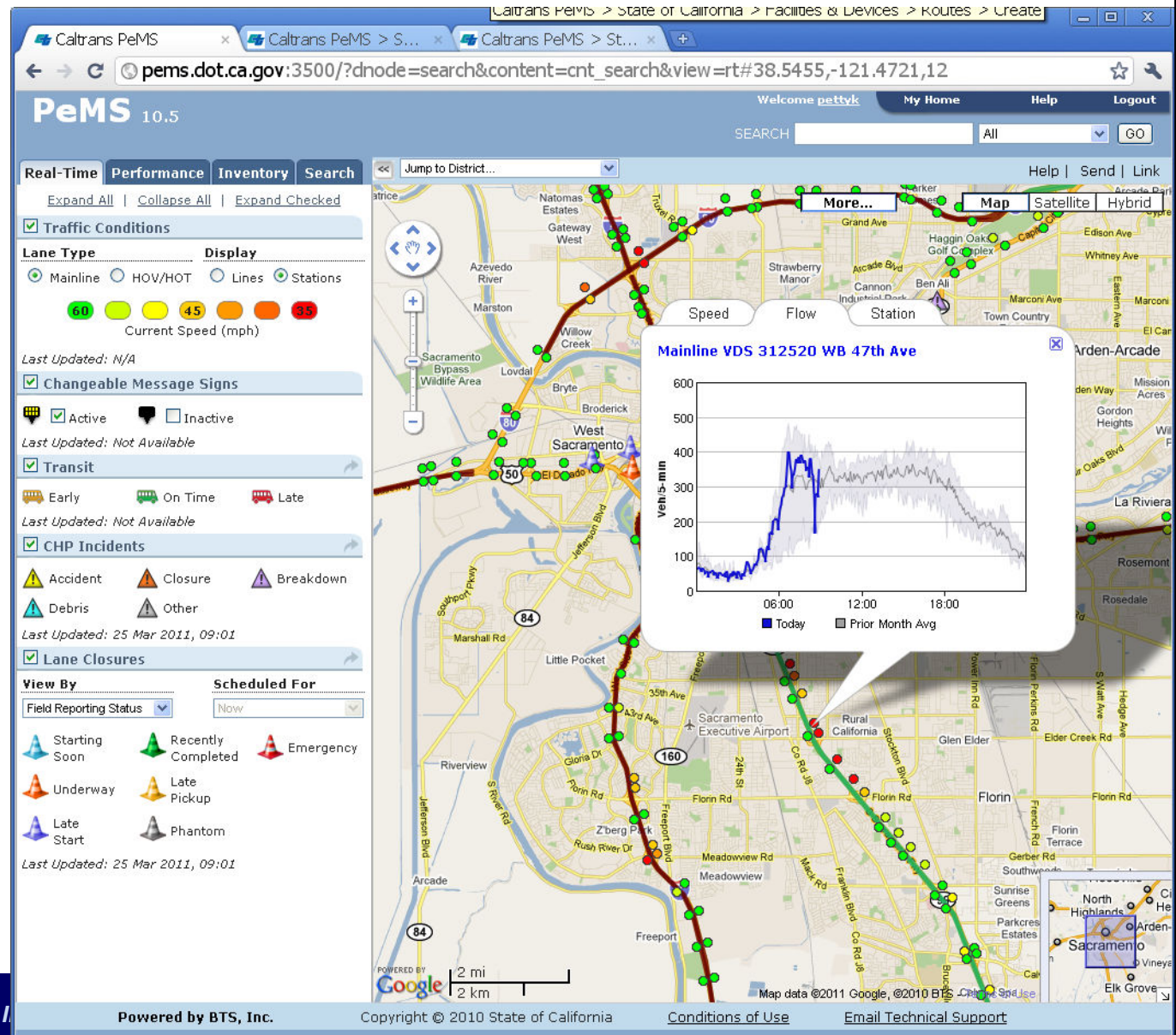


Incorporates Many Types of Transportation Data



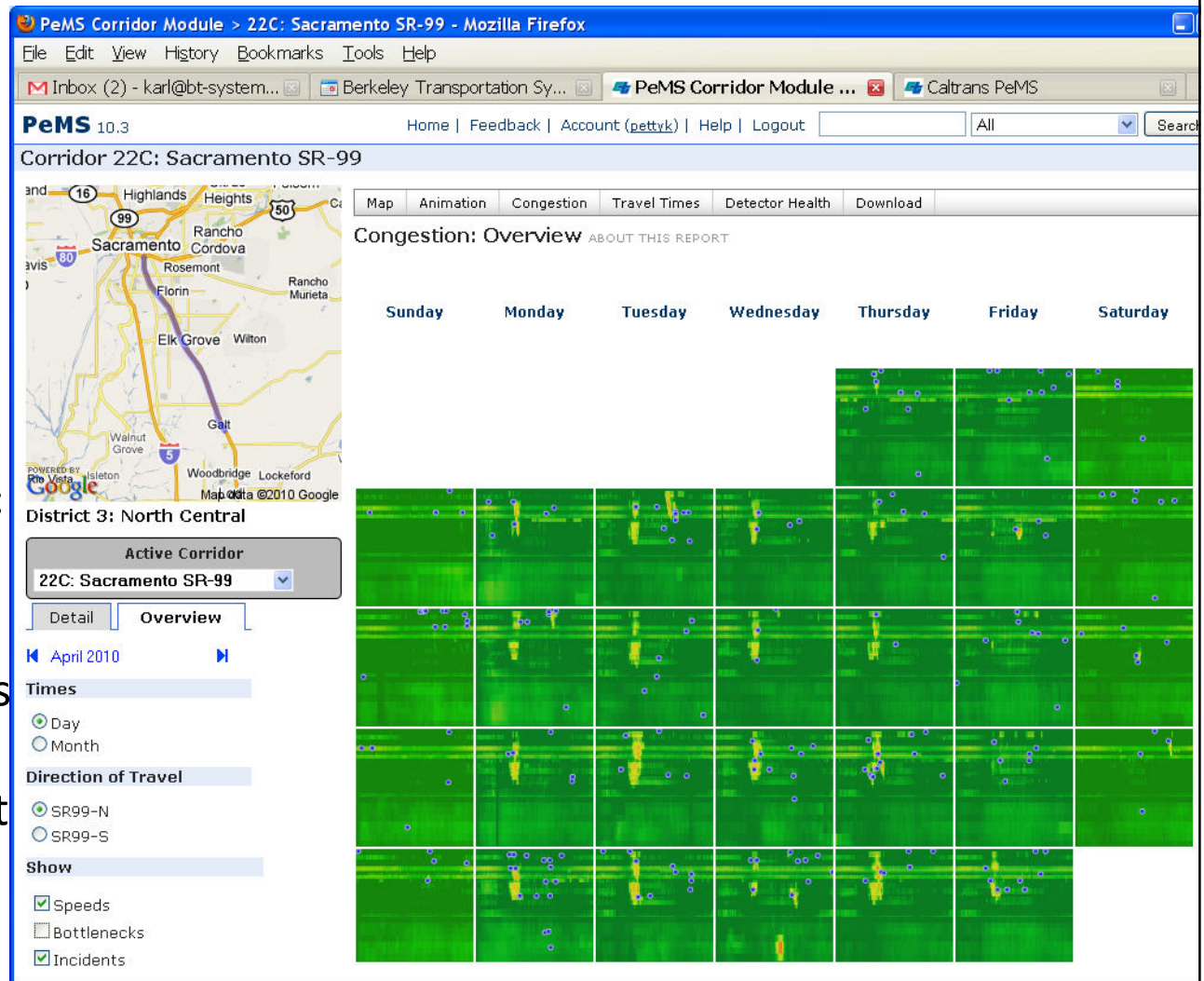
Visualization of Current Status

- Many different GIS-based displays
- We merge together the historical and real-time data in a number of ways
- Can show many different types of information on the maps
 - Roadway
 - Facility
 - Historical



High-Level Corridor Analysis

- Qualitative report for a particular corridor
- Shows “speed contour” diagram for every day in a whole month
- Can visually identify traffic patterns
- Here we’re showing traffic flowing from the suburbs to Sacramento
- We can see that on Fridays the bottleneck as we approach Sacramento isn’t there



Many, Many Types of Tools In PeMS

- Historical Analysis
 - Traditional point and spatial measures (VMT, VHT, Delay, Travel time)
- Real-Time Analysis
 - Travel time prediction
- GIS-based Tools
 - Sensor configuration management, tracking, performance reports, etc.
- Advanced Visualization Tools
 - Animations, Corridor analysis
- Managed Facility Analysis
 - Balance of demand, differences in travel time
- Traditional Count Data
 - HPMS reporting, integration with ITS data, AADT, MADT computations
- Weight-in-Motion and Vehicle Classification Data
 - WIM data analysis, load spectra reporting, classification reports
- Traffic Management Tools
 - Lane requirements chart, delay estimation analysis
- Arterial Analysis
 - Link travel times, control delay estimation, GIS displays
- Transit Data
 - Passenger count and AVL integration, on-time performance, loading analysis, travel times

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Arterial Data in PeMS

Arterial Performance Monitoring

- Benefits
 - Identify problem areas
 - Understanding control delay
 - Quantify operational improvements
 - Understand what's taking place on the network
 - Integrated with freeways (in Caltrans' version)
- Needed Inputs
 - Topology information (what are the streets and where are they?)
 - Sensor information (flows, speeds, travel times)
 - Signal timing information (static plans, real-time measurements)
- Arterial PeMS Approach
 - Sensor agnostic – PeMS takes in any type of sensor data
 - Simple loops, Video-based detection, Bluetooth tag reads, Sensys dots or re-id detectors, etc.
 - System agnostic – PeMS isn't a control system
 - Different levels of reporting based on what's being measured

Arterial Data Challenges

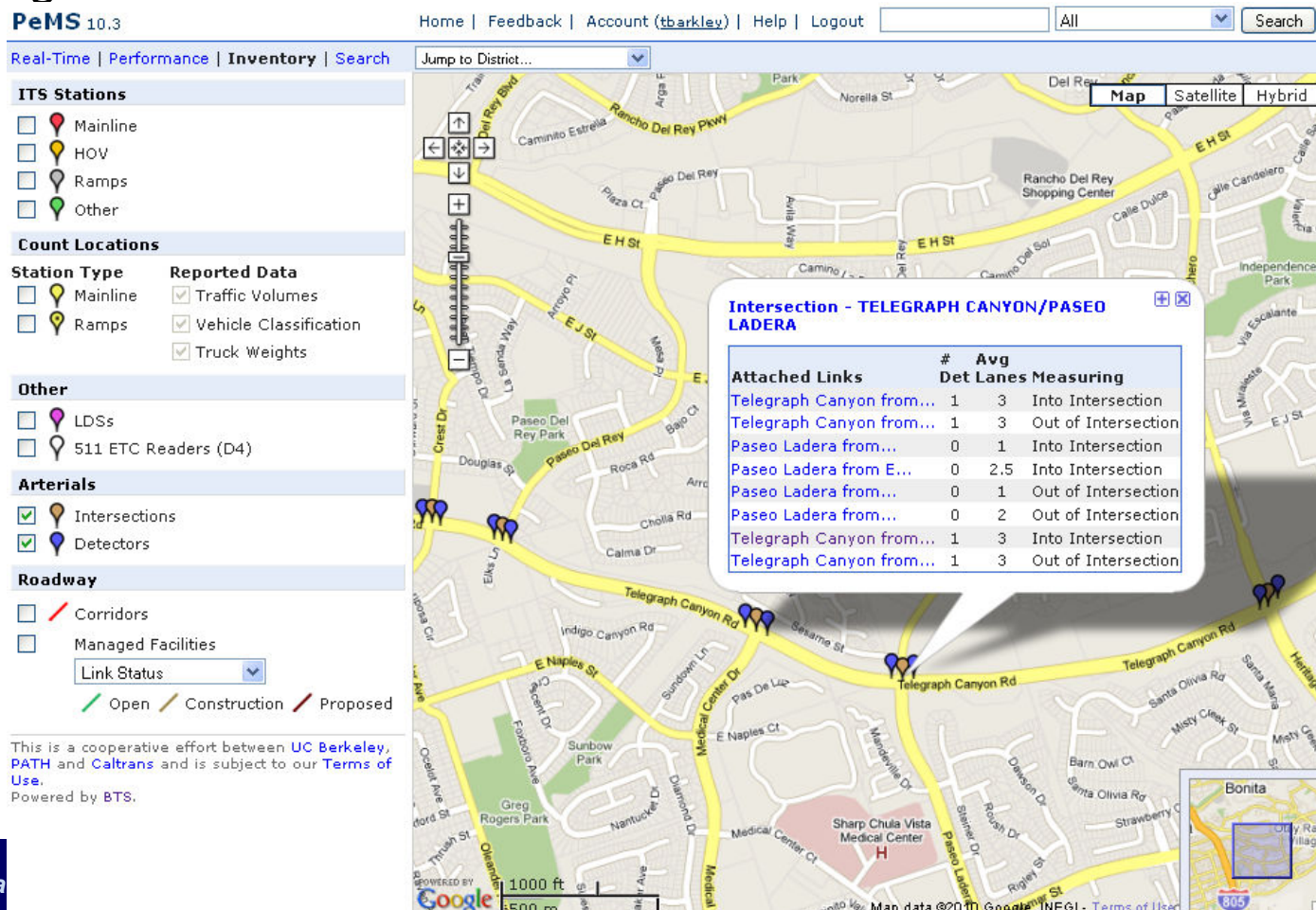
1. **Topology:** GIS linework typically doesn't have the information needed
 - Stitching together multiple sets is painful (MPO model layers, City layers, TIGER layers)
2. **Traffic Data:** Sensor locations and capabilities vary by deployment.
 - Different number of lanes, different granularities, different quantities
3. **Signal Data**
 - Some technical and political challenges in obtaining real-time controller data.
 - Without cycle-by-cycle data, we have to estimate or use timing plans.

	Chula Vista, CA	Carson, CA	City of Los Angeles
Detectors	Re-identification, Flow	Individual Vehicle Records	30-second flow and occupancy
Locations	One departure (release) lane	All approach and release locations, some midblock	Some midblock lanes
Signal Info	Time-of-Day Plans	Estimated in real-time from release detectors	Time-of-Day Plans
Size	18 detectors, 9 intersections	125 detectors, 8 intersections	18,712 detectors, 2,200 intersections

Bottom Line: The system needs to maintain a flexible (but programmatic) approach towards arterial data collection and performance computation.

Example: Chula Vista Project

- Types of performance measurement visualization
- Examples of use (standard movement reporting, signal performance, etc)
- Integrated with Caltrans' instance of PeMS



Listing of Intersections in Chula Vista

- The configuration page for an intersection
- Shows the attached links
 - Note that there is one link in each direction
- Schematic of the intersection is draw on the bottom
- The links contain the measurements

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Arterial Intersection 10006: TELEGRAPH CANYON/PASEO RANCHERO/HERITAGE

Intersection Details Signal Phase Estimation Signal Timing Plan Tools

Intersection Details ABOUT THIS REPORT

Attached Links	Travel Direction	# Detectors	Avg Lanes	Measuring In or Out
Paseo Ranchero from J to Telegraph Canyon	South	0	3	Into Intersection
Paseo Ranchero from Telegraph Canyon to J	North	0	2.5	Out of Intersection
Heritage from E Palomar to Telegraph Canyon	North	0	4	Into Intersection
Heritage from Telegraph Canyon to E Palomar	South	0	4	Out of Intersection
Telegraph Canyon from Buena Vista to Heritage	West	1	3	Into Intersection
Telegraph Canyon from Heritage to Buena Vista	East	1	3	Out of Intersection
Telegraph Canyon from Heritage to Paseo Ladera	West	1	3	Out of Intersection
Telegraph Canyon from Paseo Ladera to Heritage	East	1	3	Into Intersection

Quick Links

View nearby intersections:

Only intersections with timing plans shown.

View another intersection:

Enter an intersection ID to view this same report for a different intersection.

View intersections in:

GO

Map data ©2011 Google, INEGI

District 11, San Diego County, Chula Vista

Paseo Ranchero

Telegraph Canyon

Detector id: 10607
Turns: T

Intersection Information

- For these intersections we have the timing plans
- We look at them by day and then time of day
- The phase indication diagram shows the duration of the cycle for each phase
- The table below provides the details

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Arterial Intersection 10006: TELEGRAPH CANYON/PASEO RANCHERO/HERITAGE

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Signal Timing Plan ABOUT THIS REPORT

Sunday Monday Tuesday Wednesday Thursday Friday Saturday

Jump to timing plan for: 7:00 to 8:59

Hours 7:00 to 8:59

Control Type: ACTUATED-COORDINATED
Cycle Length: 120
Hold Release (s): 255
Offset (s):
Ring Offset:

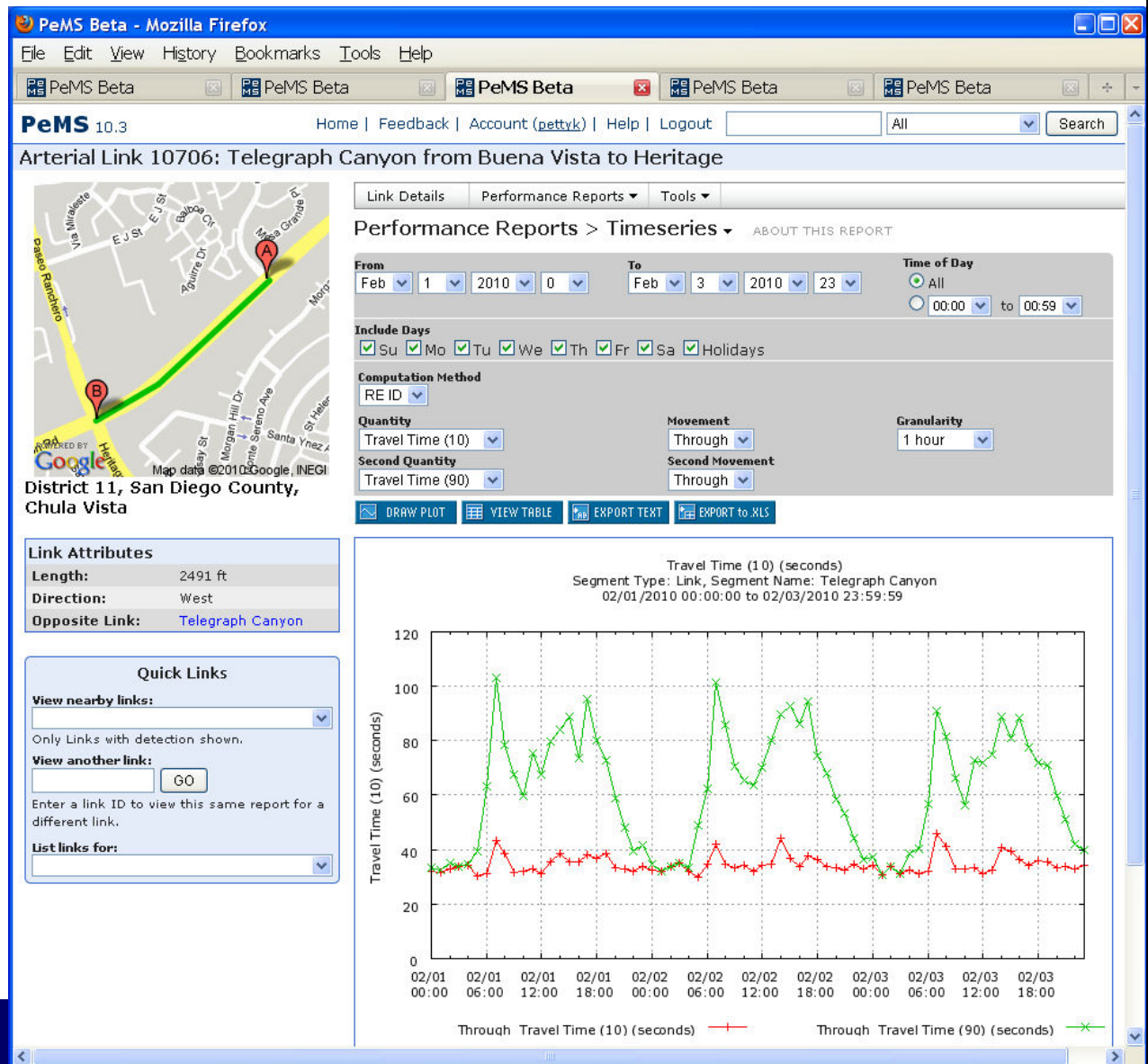
Phase Indication Diagram

Phasing Window

	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Phase Movement	WBL	EBT	NBL	SBT	EBL	WBT	SBL	NBT
Minimum Initial (s)	2.0	8.0	2.0	3.0	2.0	8.0	2.0	3.0
Minimum Split* (s)	6.0	15.0	6.0	8.5	6.0	15.0	6.0	8.5
Maximum Split* (s)	22.5	50	22	25.5	22.5	50	22	25.5
Yellow Time (s)	3.0	4.7	3.0	4.0	3.0	4.7	3.0	4.0
All-Red Time (s)	1.0	2.3	1.0	1.5	1.0	2.3	1.0	1.5
Force Off (s)	73	0	25	49	73	0	25	49
Vehicle Extension (s)	1.5	6.0	1.5	2.4	1.8	6.0	1.5	2.4
Minimum Gap (s)	1.5	2.0	1.5	2.4	1.8	2.0	1.5	2.4
Maximum Gap (s)	1.5	6.8	1.5	2.4	1.8	6.8	1.5	2.4
Pedestrian Phase?	No	Yes	No	Yes	No	Yes	No	Yes
Walk Time (s)		6.0		6.0		7.0		6.0
Flash Don't Walk (s)		21.0		24.0		18.0		24.0

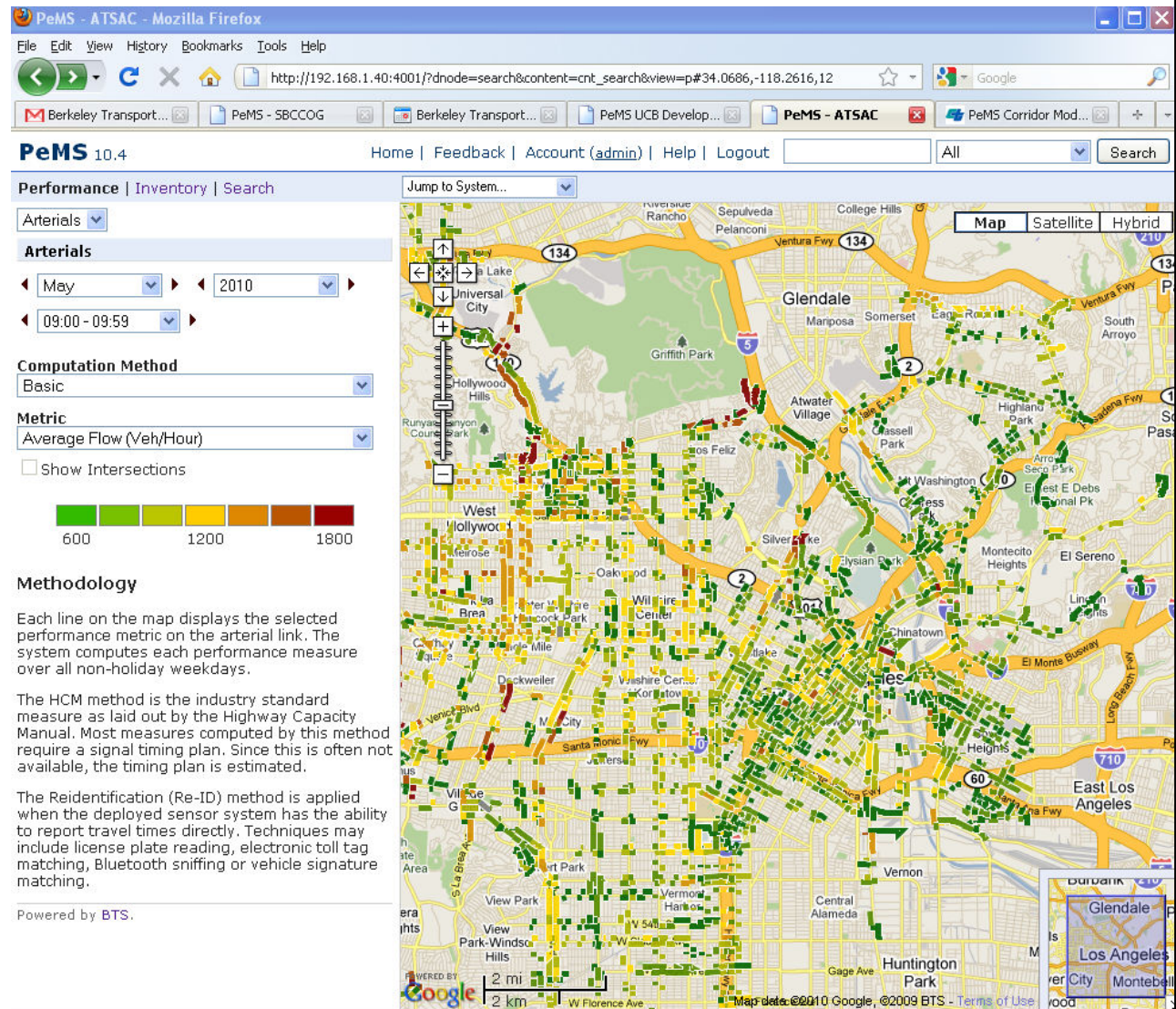
Link Reports: Flow and Travel Time

- We compute the travel time distribution for each hour (based on all the matched vehicles)
- We store the following percentiles:
 - 0th (minimum)
 - 10th
 - 25th
 - 50th (median)
 - 75th
 - 90th
 - 100th (maximum)
- Here we're showing the 10th and 90th percentiles (ie: 80% of the vehicles had travel times between these times)



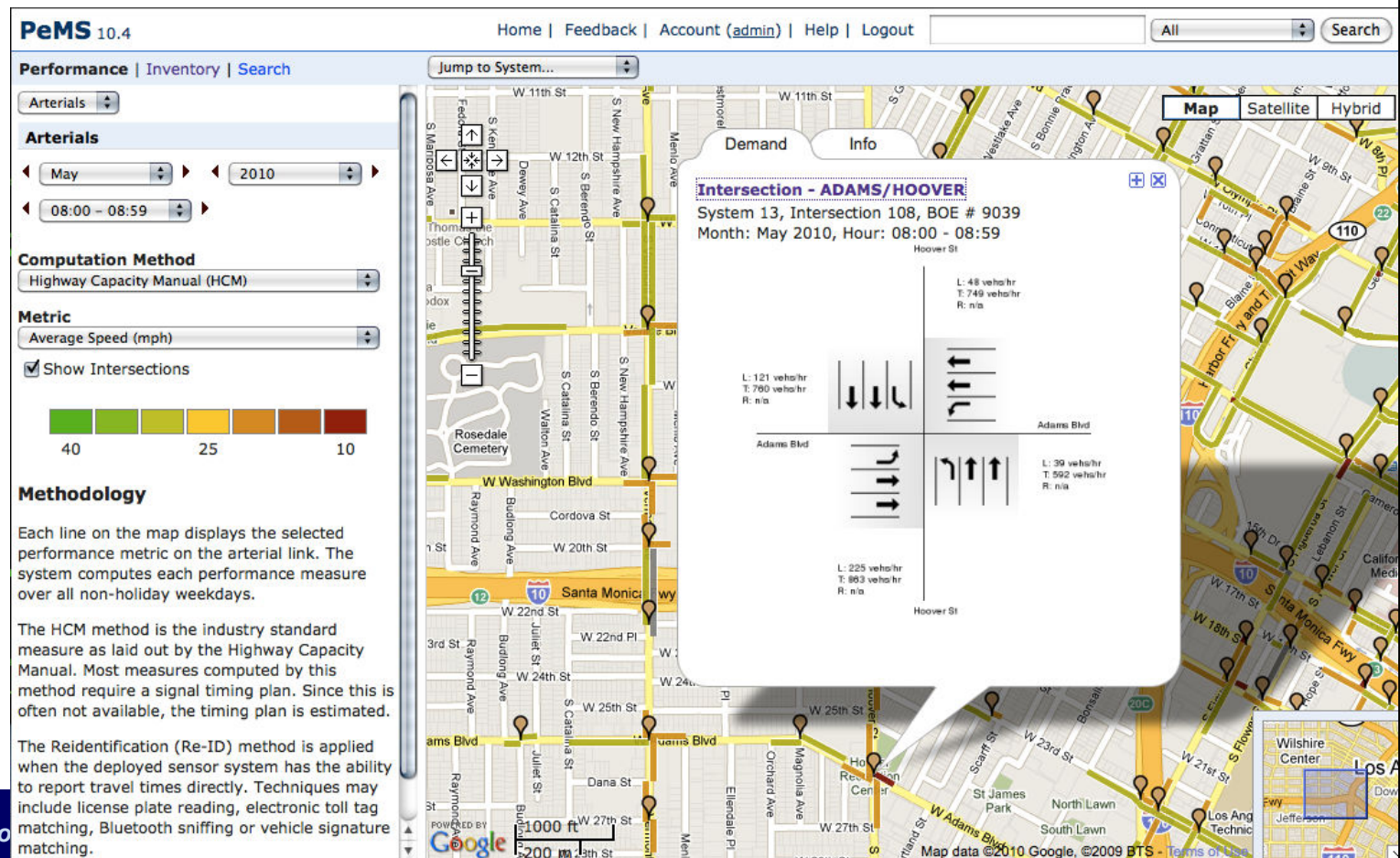
Example: City of Los Angeles

- Integrated with
ATSAC data
- Performance maps
can show flow,
density, and speed
averaged over a
user-selected month
and hour of the day
- Here, we are
mapping flow at
9:00 AM and can
easily spot high-
demand areas.



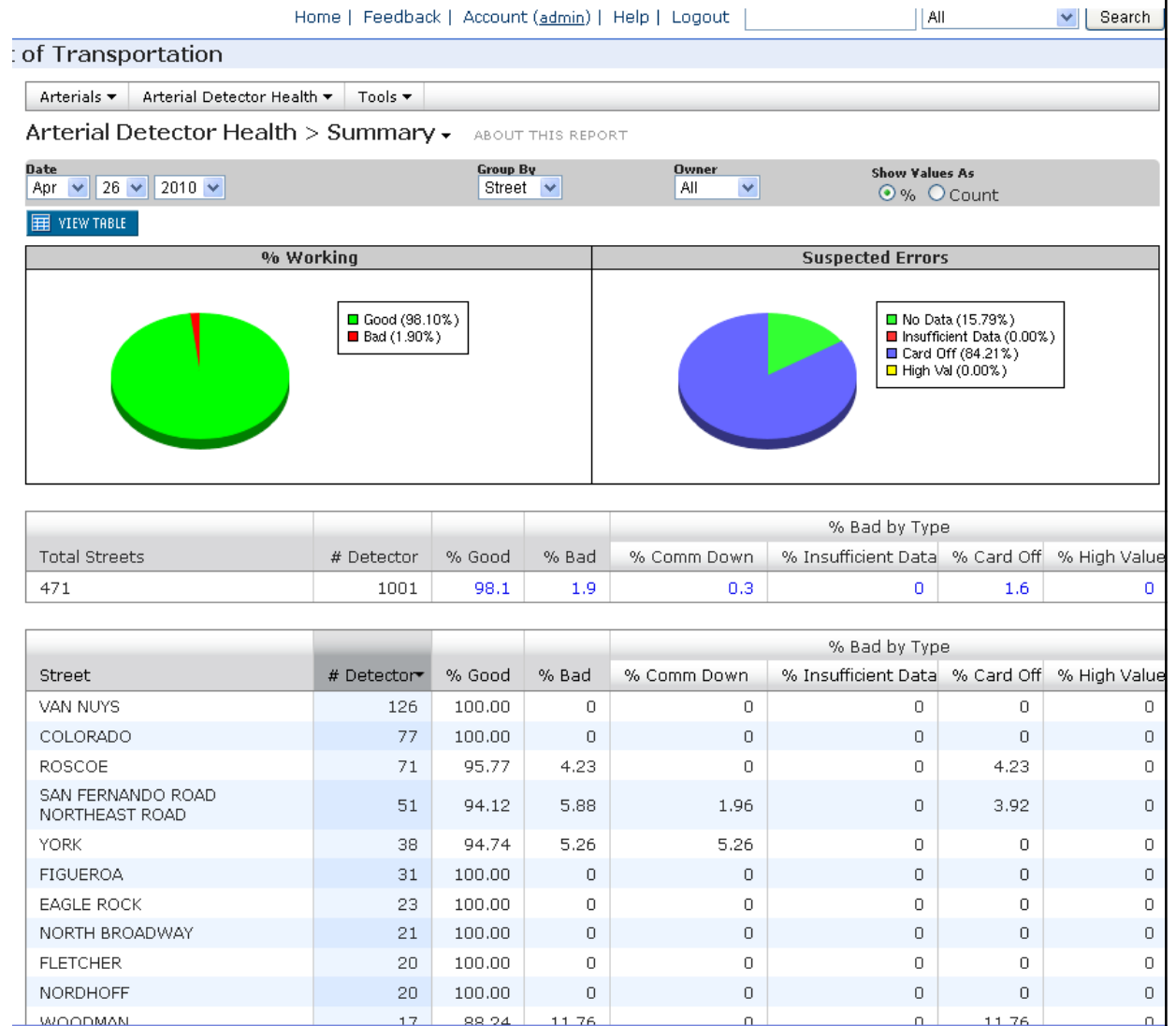
Investigating Data

- Can turn on intersections and get turning count diagrams
- Way to browse data to understand trends easily
- Can drill down to the timeseries trends from here



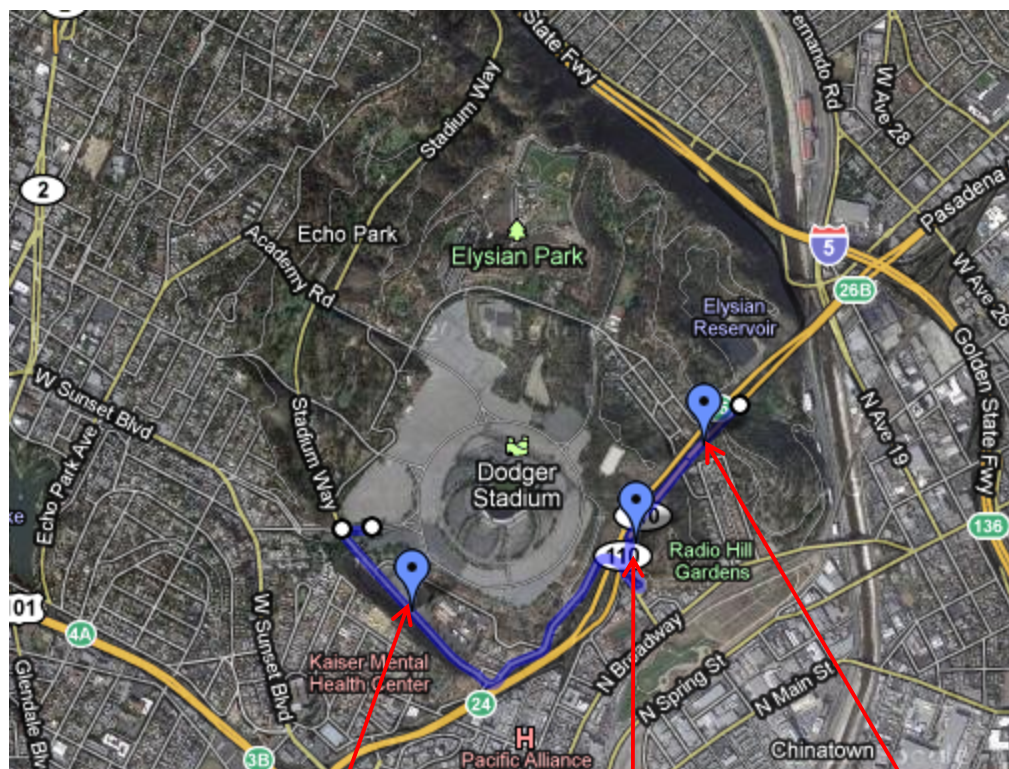
Assessing Detector Health

- PeMS assesses the health of every sensor in the system every night
- Users can see a daily summary of overall and city-by-city or street-by-street detector health
- When detectors are not working, we attempt to diagnose the problem
- Users can also drill down to see where, when, and why specific detectors were broken



Investigating Arterial/Ramp/Freeway Data

- Arterial and Freeway data integration lets users compare the patterns between arterial, freeway, and ramp traffic.
- Special events typically start on arterial streets and then effect freeways
- Example: How do Los Angeles Dodgers home games impact traffic on the various facilities near the stadium?



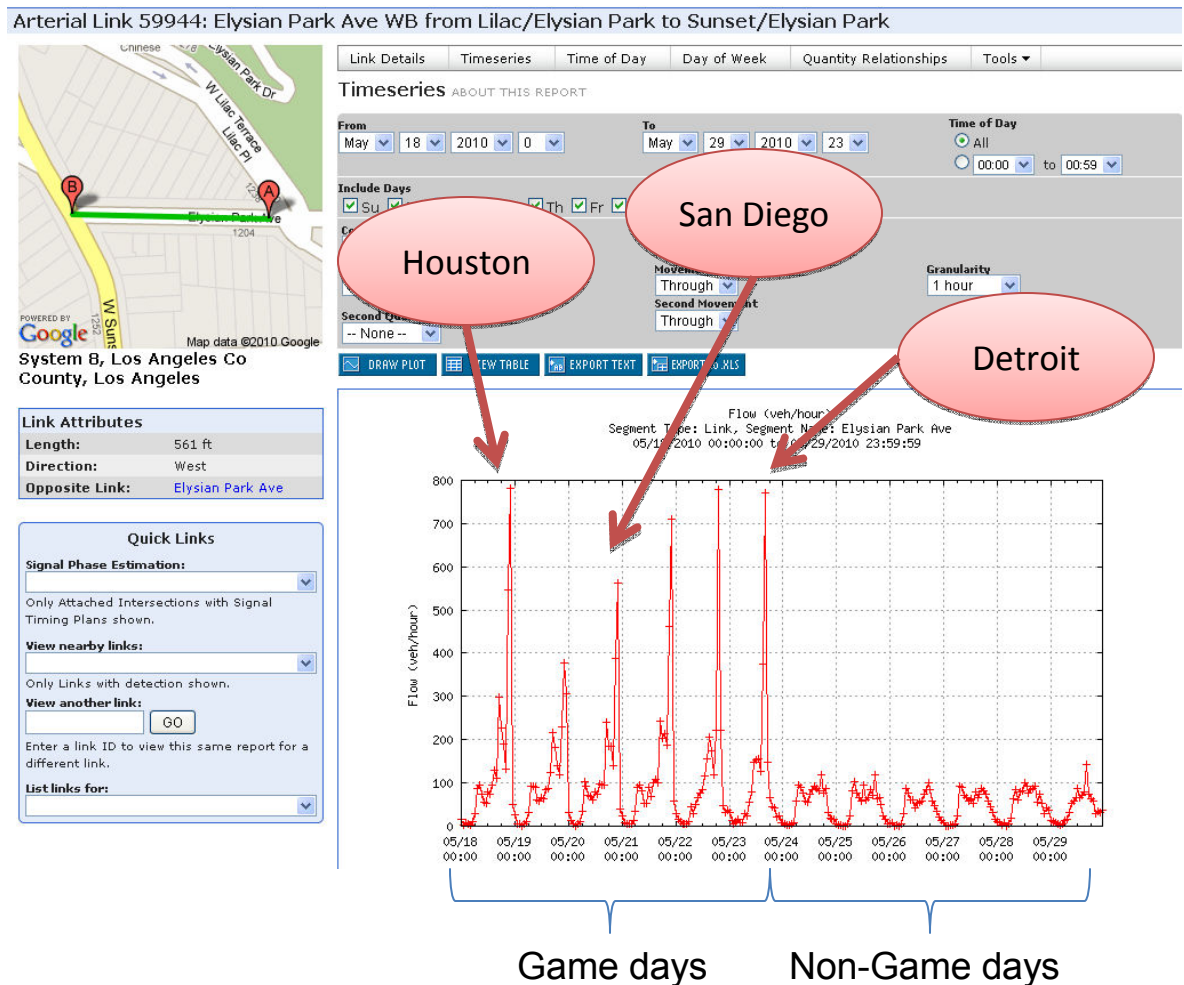
Arterial Detection

On-ramp detection

Freeway detection

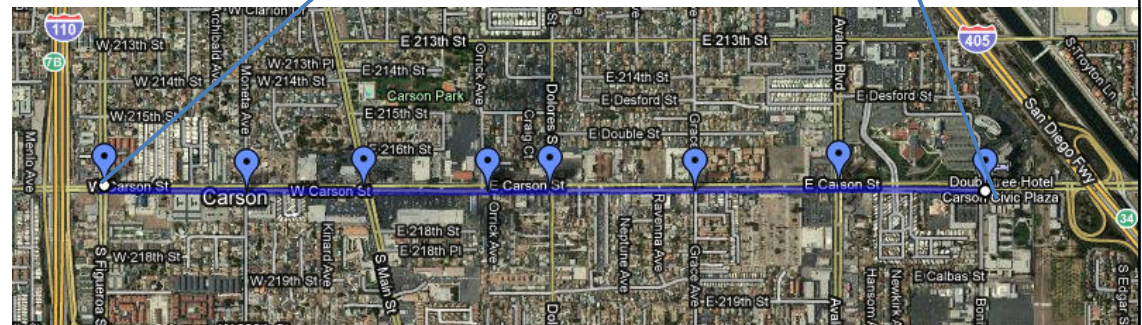
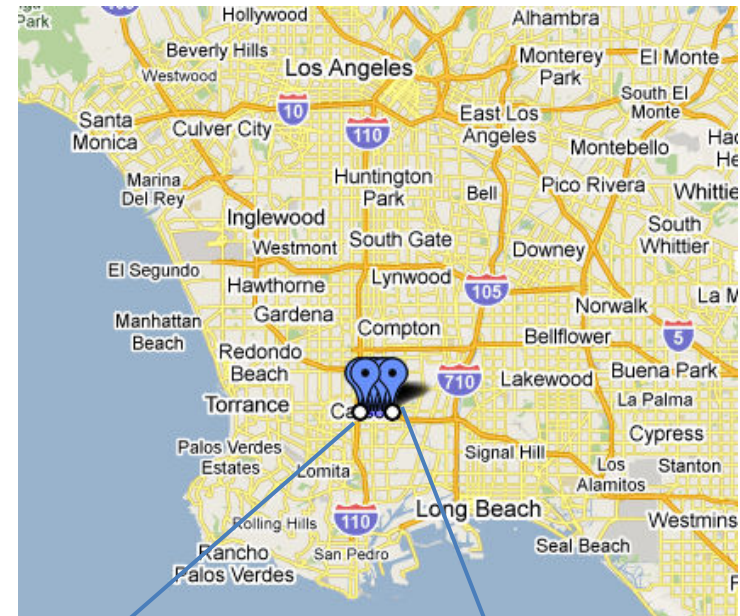
Special Event Arterial Traffic

- Here, we are plotting hourly volumes over 12 days at an arterial stadium exit.
- First 6 days are Dodger Home Games.
- Huge spike in volumes post-game (600-800 veh/hour), close to midnight
- Can clearly see the effects of special events
- In an integrated system (with freeway data) we can pursue where the freeways are overloading



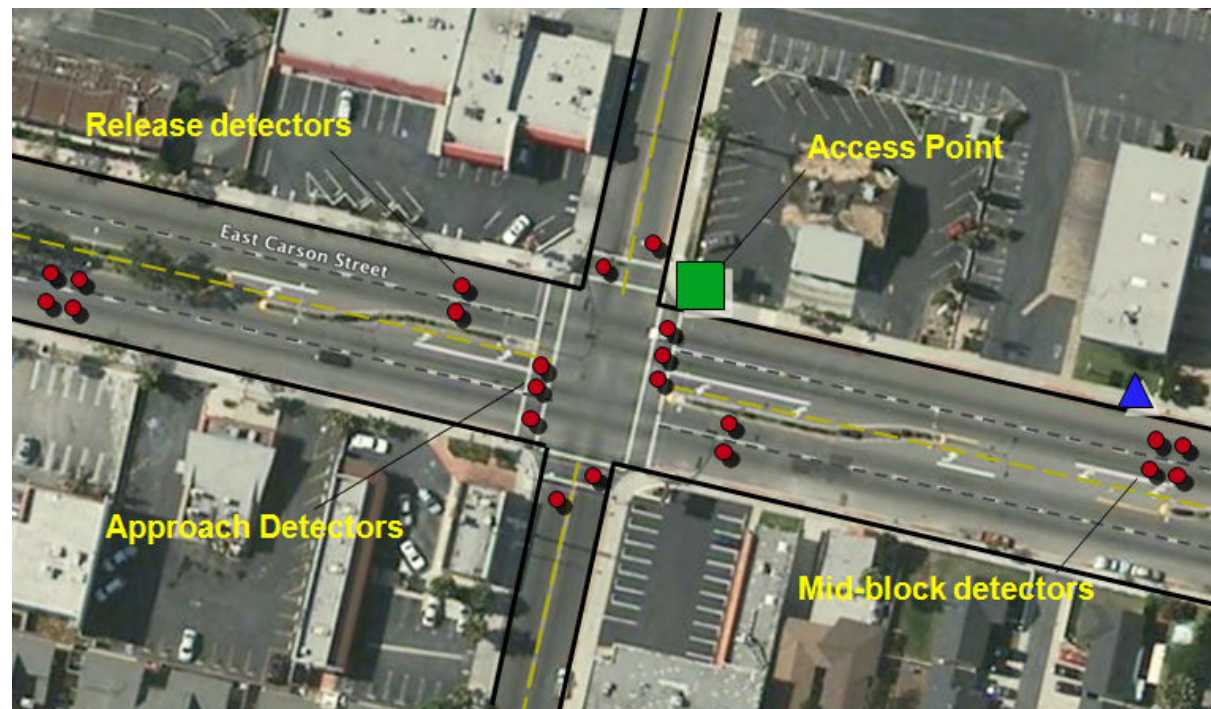
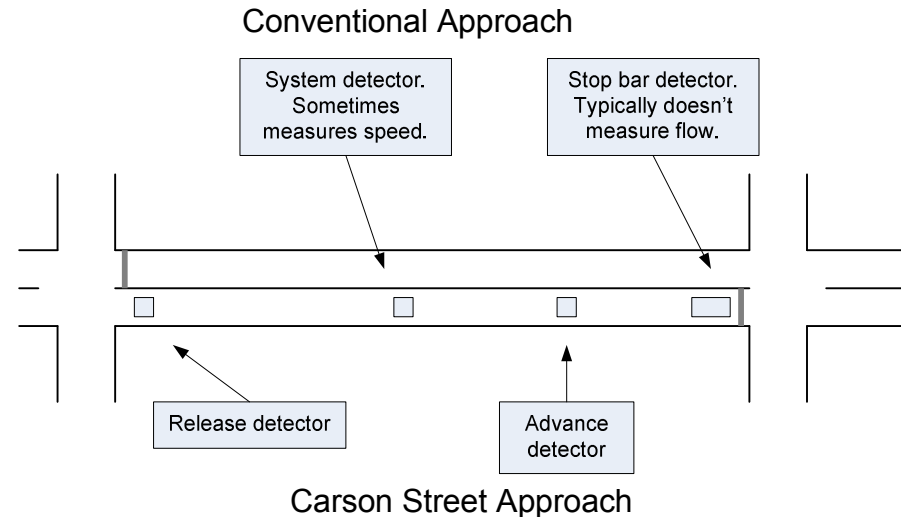
Example: Carson

- Characteristics
 - 1.8 mile corridor in Los Angeles's South Bay
 - 8 signalized intersections
 - Commercial/industrial/residential land uses
- Importance
 - City and County signal timing responsibilities
 - Recently coordinated
 - Proximity to managed freeway corridors
 - Just west of a designated truck route



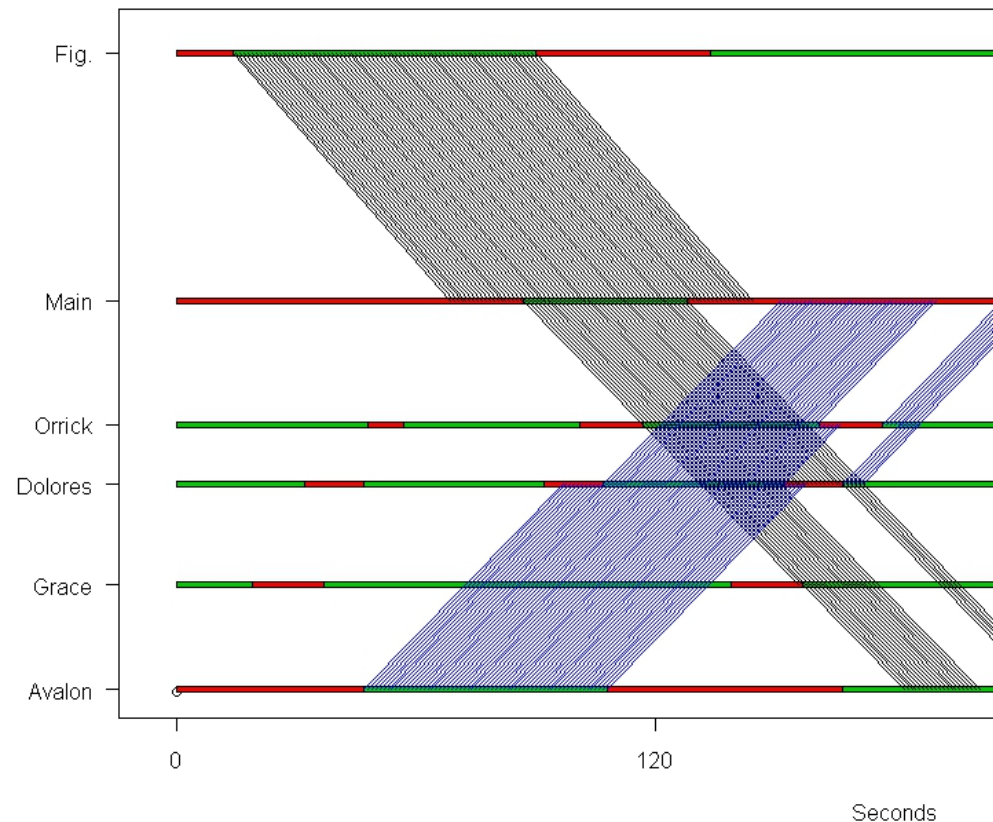
Detection

- Difficult to convert existing detectors for traffic monitoring purposes
- Solution: Install Sensys Wireless Vehicle Detectors
 - All approach lanes (in crosswalk)
 - Some departure lanes
 - Four midblock locations (speed)
- Send data for each vehicle detection
- Installed June 2009



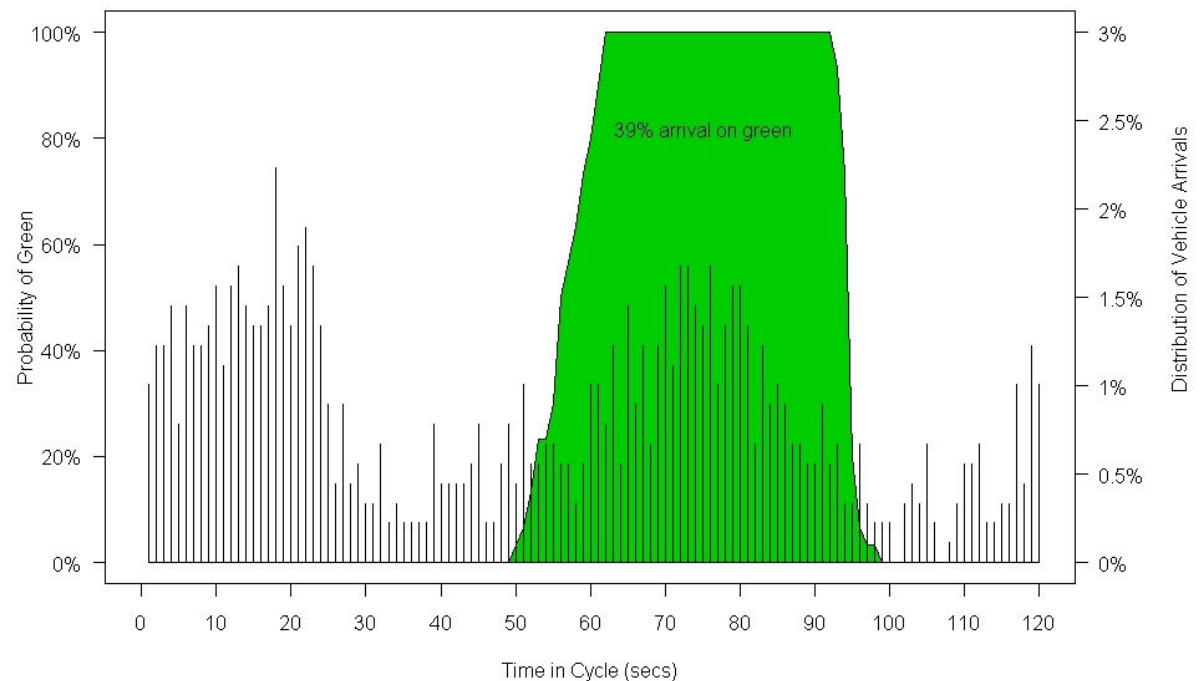
Visualizing Corridor Performance

- Time-Space Coordination diagrams generated for coordinated systems and time periods
 - Need to have known offsets between intersections!
- X-axis: Time
- Y-axis: Distance down corridor
- Horizontal lines: when an intersection is green (or red)
- Slope of lines represent the speed limit
- Speed limit and timing plan offsets used to show progression quality



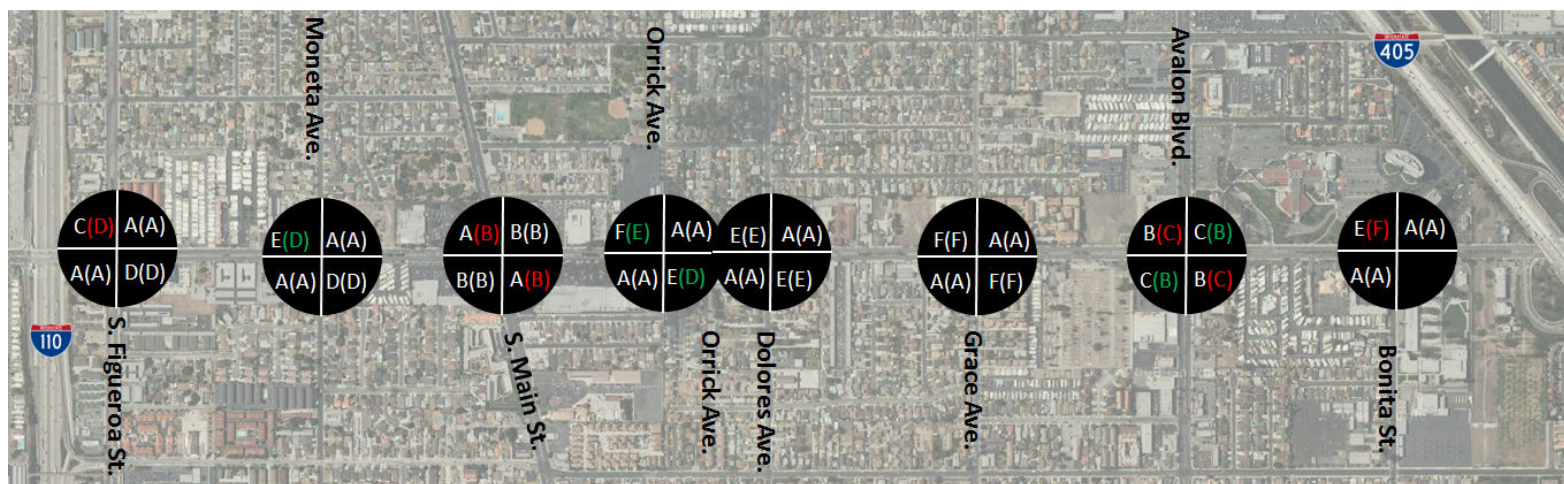
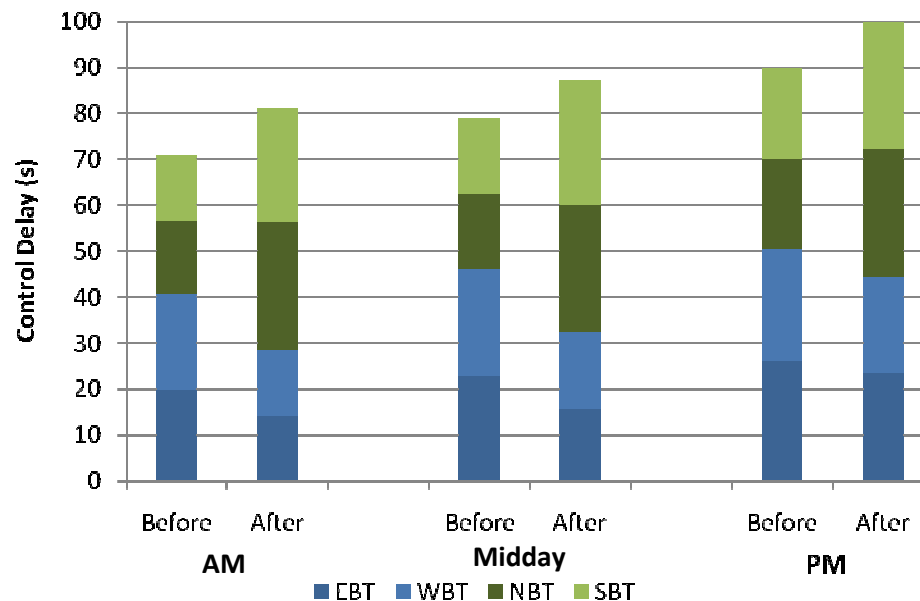
Visualizing Intersection Performance

- As a function of the time in the cycle:
 - When do vehicles arrive at an intersection?
 - When is the light typically green?
- Show the average fraction of vehicles during the cycle that arrive on green at an intersection
- Only 39% of the vehicles have arrived on green for this link
- Adapted from the “Purdue Coordination Diagram” (PCD), by Day, Bullock, *et al* at Purdue.



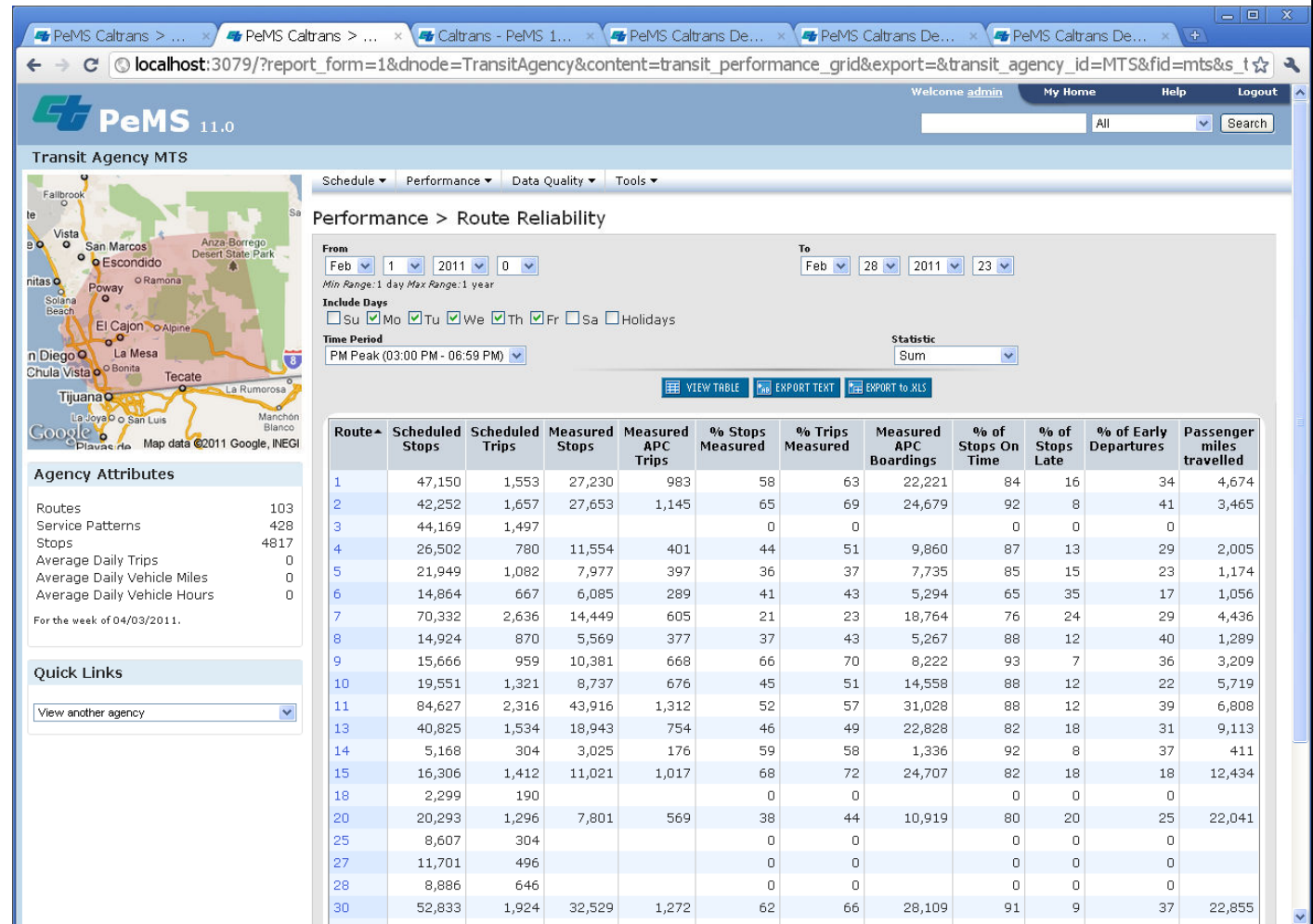
Control Delay Results

- Control delay reduced at nearly all Carson intersection approaches.
- Cross-street and total intersection control delay increased.



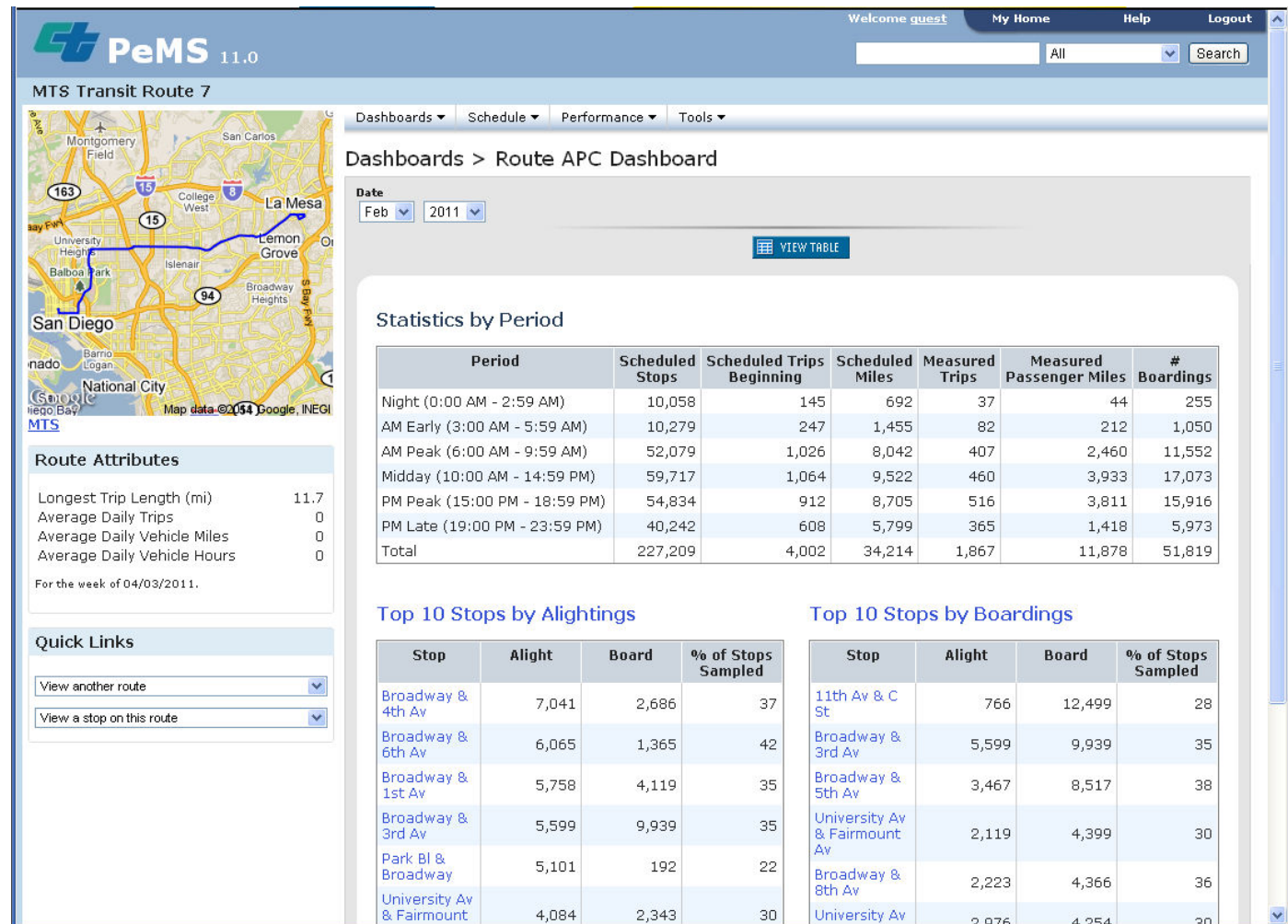
Agency-wide Route Comparison Measures

- Shows summary statistics for all routes for a given time range
- Users can see the sum or the average (per day) for the various values
- Clicking on the route can jump to the route page



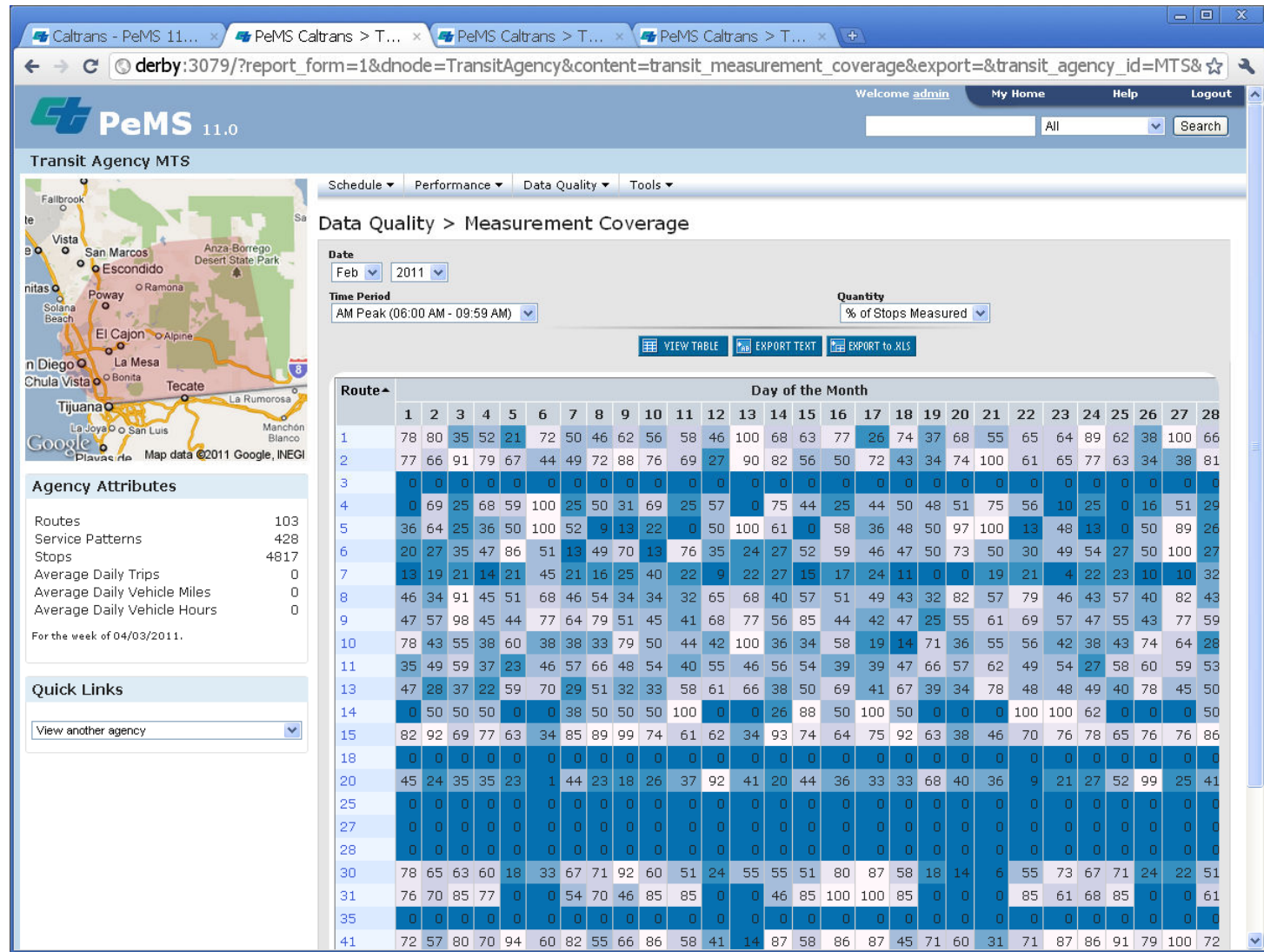
Single-Route Dashboard

- Starting page for a single route
- Shows some summary performance measures for the route by month
- We showing a combination of scheduled information and measured information
- As well as the top stops by boardings and alightings



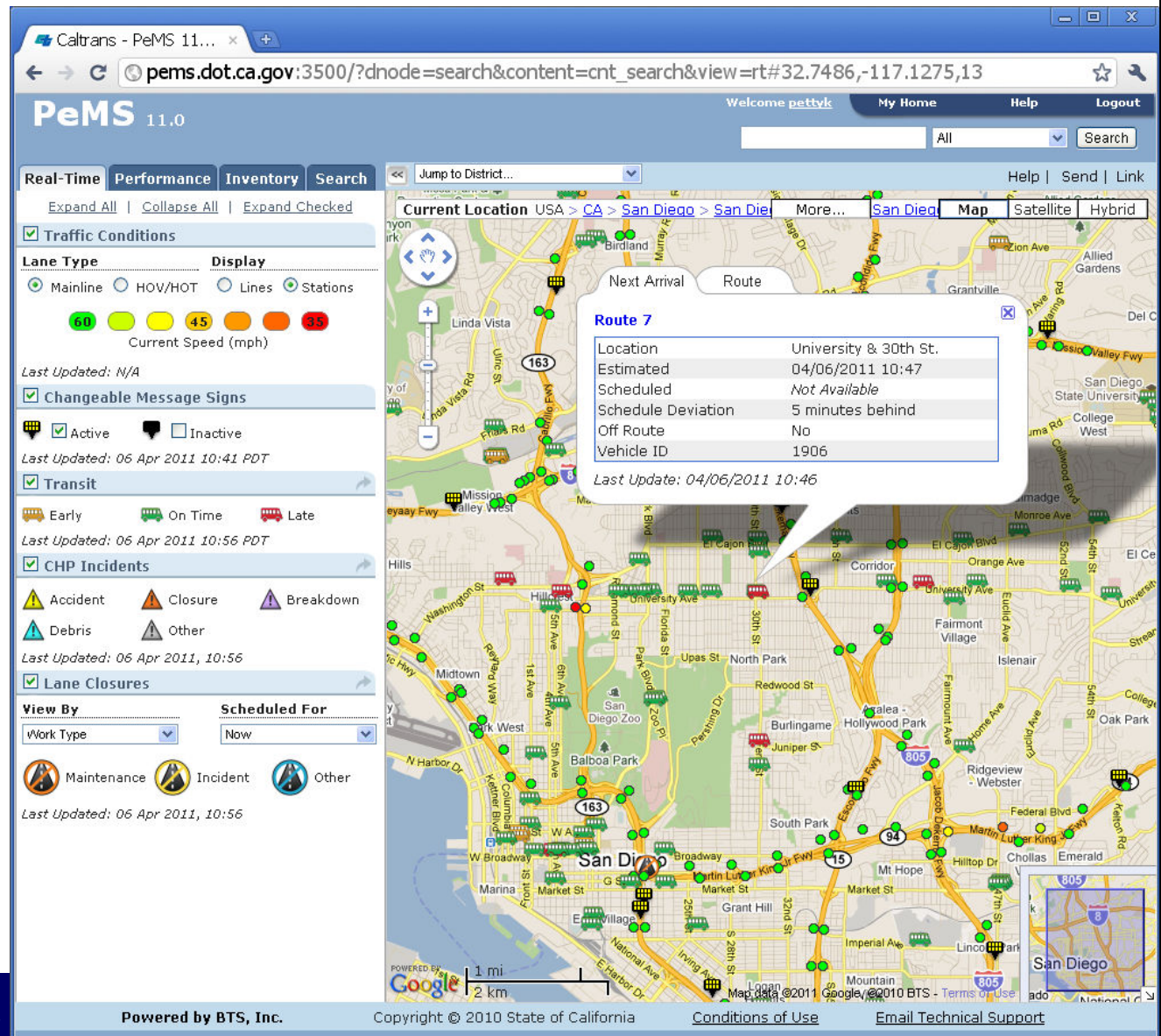
Measurement Coverage: Stops

- % of stops that are measured in the AM Peak period
- Measured means that an instrumented bus drove by (not that it stopped)
- Some routes and days had 100% coverage for all stops (all buses on all trips were instrumented with APC counters)

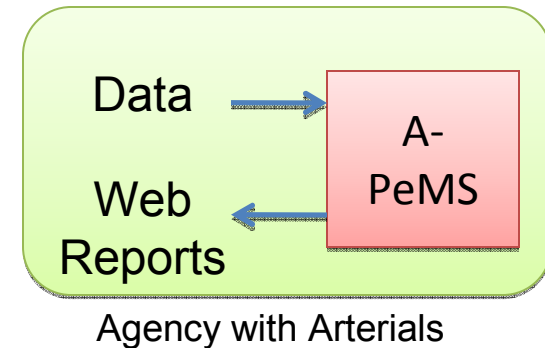
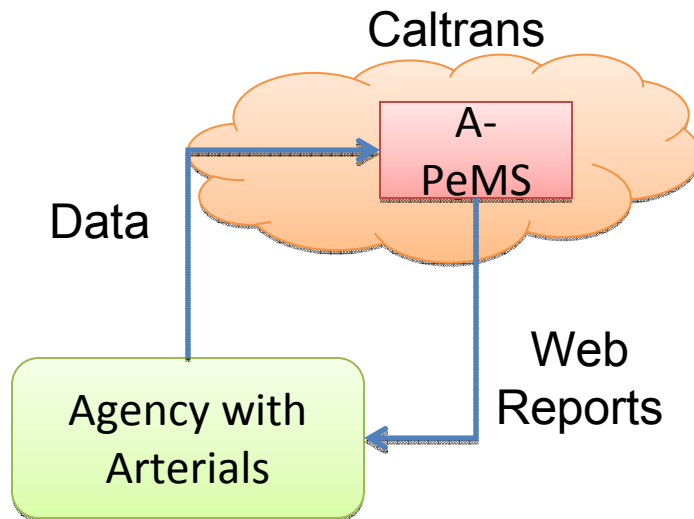


Buses on Maps

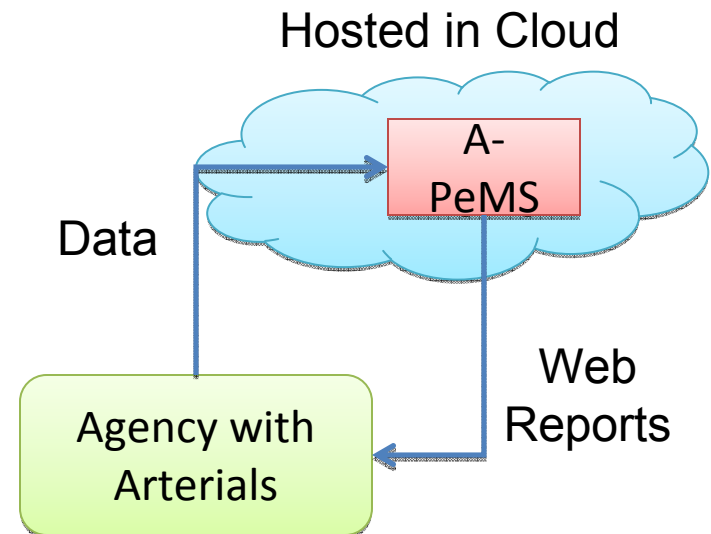
- We're grabbing the AVL data
 - Through a bad hack
- Placing the buses on the real-time map in PeMS
- Infowindow shows what comes across in the XML feed
- We color them as to whether they're early, on-time or late



Deployment Options



1. Integrated with Caltrans' PeMS
 - They are interested in corridor management
 - Have agreed in the past to take in partner data
2. Standalone
 - Not part of Caltrans' PeMS, inside of agency
 - Allows for customization
3. Standalone, but Hosted
 - Similar to standalone, but hosted (no IT issues)



Summary

- Arterial corridor management needs
 - Different approach from freeways
 - Solid detection infrastructure
 - Automated process for data collection and processing
 - New data storage and computation framework
 - Dynamic system, not a static report
 - New arterial-based visualizations
- A-PeMS provides one way to achieve this
 - Sensor and system agnostic
 - Flexible deployment options
 - Extensible features
 - Integration with other California data sets

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Questions